Environmental Science and Policy 82 (2018) 117–125

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

An operation on 'the neglected heart of science policy': Reconciling supply and demand for climate change adaptation research

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ARTICLE INFO

Keywords:
Science policy
Adaptation
Climate change
Sustainability science
Natural resource management

ABSTRACT

We report on an initiative that sought to negotiate the intersections of science, policy and practice through reconciling supply and demand (RSD) for research. We propose a synthesised framework that can be used to either inform or analyse the practice of RSD, then examine an Australia-wide program that was designed to link research with strategic regional planning for climate change adaptation in natural resource management. Cross-scale lessons from this endeavour at national (program), and regional (project) scales suggest that framing RSD in opposition to linear or deficit approaches that hinge on delivery of scientific information presents an incomplete view. RSD engages with pre-existing institutionalised practices and understandings and in doing so changes both the supply (research) and demand (policy/practice) side. In the case examined here, scientific information products were initially prioritised by funders over processes for collective knowledge generation. However a widely acknowledged need for capacity building and co-creation ultimately informed project activities. We argue that in taking RSD seriously, programs and projects will often need to actively shift their focus from the delivery of *information products* towards prioritising less visible *processes and outcomes*. Combined process- and outcome-orientation, in turn, must pay attention to expert legitimization, and how knowledge can have a bearing on (and potentially change) established institutions and practices of decision-making.

1. Introduction

As ecological decline continues, exacerbated by climate change, attention to achieving societal outcomes by linking science, policy and practice to broader society is growing (e.g. Leith et al., 2017; McNie et al., 2016). This attention is, in part, a consequence of viewing public investment in environmental science as key means of addressing sustainability challenges. Repetitive failure of models that assume science will speak truth to power fomented a recognition that knowledge generation on its own is insufficient and may be even an unnecessary contributor to resolving complex problems (Sarewitz, 1996). This is especially so where stakes are high, values divergent, and political will to consider future generations and other species is weak. Numerous approaches have been suggested to better work across research, policy and politics ranging from transdisciplinary research (Hadorn et al., 2006) mode-2 science (Nowotny et al., 2001), post-normal science (Funtowicz and Ravetz, 1993) and co- production (Armitage et al., 2011). Such approaches are founded on commitments to developing knowledge that speaks to the vagaries of human values and concerns whilst maintaining methodological rigor. They reflect the interdependence and trade-offs between research legitimacy, relevance and credibility (Cash et al., 2003) and negotiate differences in worldviews, epistemologies, institutions and cultures among people engaged in research (Leach et al., 2010). They recognise that linking research and decision- making for sustainability is situation specific, often politicised, and founded in relationships among people, societal rules and norms (institutions) and discourses that define the validity and usefulness of knowledge (Jasanoff, 2004).

This paper contributes to finding ways through these challenges in two steps. Firstly, in Section 2, we build on and extend the influential work of Sarewitz and Pielke (2007) and McNie (2007) on Reconciling Supply and Demand (RSD) for research. We link RSD with the emerging agenda of sustainability science (Kates et al., 2001) and its emphasis on knowledge co-production (Clark et al., 2016). We attempt to encapsulate calls for a shift in science policy for sustainability within a framework for enacting RSD in practice.

Secondly, we present an account of how this approach to RSD played out at program and project levels. The program in

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https://doi.org/10.1016/j.envsci.2018.01.015
Received 9 August 2017; Received in revised form 21 January 2018; Accepted 22 January 2018
1462-9011/ © 2018 Published by Elsevier Ltd.

question—The Regional Natural Resource Management (NRM) Planning for Climate Change Fund—operated across Australia over 4 years from 2013 to 2016. Its overall aim was to assist regional NRM organisations to update strategies to effectively consider climate change. Taken together, the program and project are presented as an 'operation' on what Sarewitz and Pielke (2007) refer to as the 'neglected heart of science policy'. Where Sarewitz and Pielke suggest assessment of the efficacy of links between research program design and the desired societal outcomes, this 'operation' represents an attempt to proactively and iteratively build these linkages. We detail the substantial efforts to co-produce knowledge with decision-makers and to use research to build capacity, skill, and self-efficacy to contribute to outcomes among both planners and researchers. These efforts ended up being largely concealed by traditional, output-oriented metrics of project success, and demarcation of roles across boundaries between research and decision-making.

2. RSD in sustainability science

2.1. Linear and deficit models and their currency

While sustainability science emphasises the need for collaborative inter- and trans-disciplinary research, in order to understand and address complex challenges (Kates et al., 2001), traditions of separating science from (and prioritising it in) societal decision-making have resisted critique (Wynne, 2014). These 'models' are probably better considered as institutionalised assumptions about legitimate roles of science in society that pervade the discourse and practice of science and decision-making. The linear model for example suggests that 'basic', 'foundational' or 'pure' science become useable through 'applied science' via policy-making, or innovations and technologies. The deficit model similarly rests on the premise that basic science of nature or society enlightens civil society, often construed as an undifferentiated public, or specific decision-makers, who need research to understand problems better.

These models imply that decision-makers share an instrumental and strategic rationality and seek to use credible scientific information as the basis of their decision-making. In their extreme form, these models link the refinement of scientific information through self-directed research by scientists with an assumed deficit of knowledge among citizens and decision-makers (Sarewitz, 1996). The result is a common depiction of problems as technical, and a tendency to downplay cultural, social, political (and so on) aspects (Leach et al., 2010; Li, 2007; Wynne, 2014). Hoppe et al. (2013) argue that the language of the deficit and linear models provide conveniently tidy 'front-office' narratives that delineate the work of researchers from those of policy-makers and practitioners. When examined closely however, these clean demarcations give way to negotiated boundaries through which authority and legitimacy are contested and defined (Jasanoff, 1987).

2.2. Sustainability science, co-production and reconciling supply and demand

Kates et al. (2001, pg. 641) suggested that making sustainability science knowledge useable required new forms of action and interaction that were "not ordered linearly in the familiar sequence of scientific inquiry, where action lies outside the research domain". Critically, this meant the intent of sustainability science was not just to understand these interacting systems, but to influence them. This, in effect, brought governance and politics squarely into the remit of sustainability science. It emphasised the need for knowledge about, and skill to conduct, transparent and equitable processes, as well as the need for trust among those engaged (Clark et al., 2016). Research embedded within communities of practice, place, or interest suggests very different forms of research from universal and generalizable science. They require differing roles of individuals (Pielke, 2007), methods of engagement with stakeholders in knowledge production (Leith et al., 2017) and structures and institutions that enable collective action without undermining rigour (Guston, 2000).

Linking science, society and policy in sustainability science, has been examined in detail by scholars of Science and Technology Studies (STS). Particularly accessible, pragmatic, and theoretically informed synthesis of this literature are approaches to reconciling supply and demand (RSD) for research (McNie, 2007; Sarewitz and Pielke, 2007). RSD focuses analysis on the active, negotiated boundaries among science, society, and policy. Rather than assuming any party can or should define research foci, frame problems, select priorities, or define 'desirable' outcomes, RSD explicitly embraces iterative and relational work at the boundaries between science, policy and society. Sarewitz and Pielke (2007) argue that we need to closely examine processes of science and research (the supply side) as well as the concerns of policy-makers and publics (the demand side) in relation to any specific issue. This approach pays attention to information asymmetry: scientists are in some sense naïve of demand and decision- making context, while decision-makers are not fully aware of the possibilities and implications of research. As Sarewitz and Pielke (2007:8) demonstrate, "the supply of science is often responsive to the presence of a well-articulated demand function" such as that of industry or military sectors. However, in sustainability issues typified by high stakes, divergent values, substantial scientific uncertainty, urgency for decision-making (Funtowicz and Ravetz, 1993), and competition among stakeholders to frame both problems and solutions (Hoppe, 2010) the demand function needs to be co-created with supply. Here RSD becomes about mediating and negotiating among groups in order to ensure research can effectively and equitably contribute to outcomes agreed on by those groups.

McNie's (2007) synthesis of literature from STS identifies numerous elements involved in RSD for such complex sustainability problems. While these are not straightforward, we suggest they can be encapsulated by three interacting goals for RSD initiatives: they should be demand-driven, problem- focused and outcome-oriented (see Fig. 1). These imperatives and their sub-categories can be considered in normative and analytical modes. In the normative mode they provide principles that researchers or science policy decision-makers might use as design considerations to plan and coordinate activities. While there is some empirical support for their application (see McNie, 2007) they still require evaluation in differing contexts. In this paper, the framework is used analytically to examine the program (Section 4.1) and project (Section 4.2) through narrative accounts.

Where the three broad imperatives overlap there are specific action areas and challenges for RSD initiatives (see Fig. 1):

1) Collaborative framing of problems, with relevant experts and decision-makers being oriented by the demand function, but critically and reflexively open to exploring alternate possible ways of framing the problem.
2) Opening up and closing down discussion, particularly in moving from problem framing to identifying outcomes and then action that can contribute to them; but also in identifying types and extent of uncertainty, and how these will be used, dealt with or delimited.
3) The negotiation of the salience, credibility and legitimacy of outputs (tangible products or things such as reports, maps and graphs) and processes that are devised to achieve outcomes (effects or impacts).
4) At the heart of RSD lie principles related to relationships among the people involved, their accountability to each other, and their use of processes in purposeful, iterative, and reflexive ways to negotiate meanings of problems and pathways to outcomes.

3. Methodology

The empirical material used for this paper spans a period from 2011 to 2016. They range from Australian Government publications to notes from project workshops and discussions, to formal interviews across

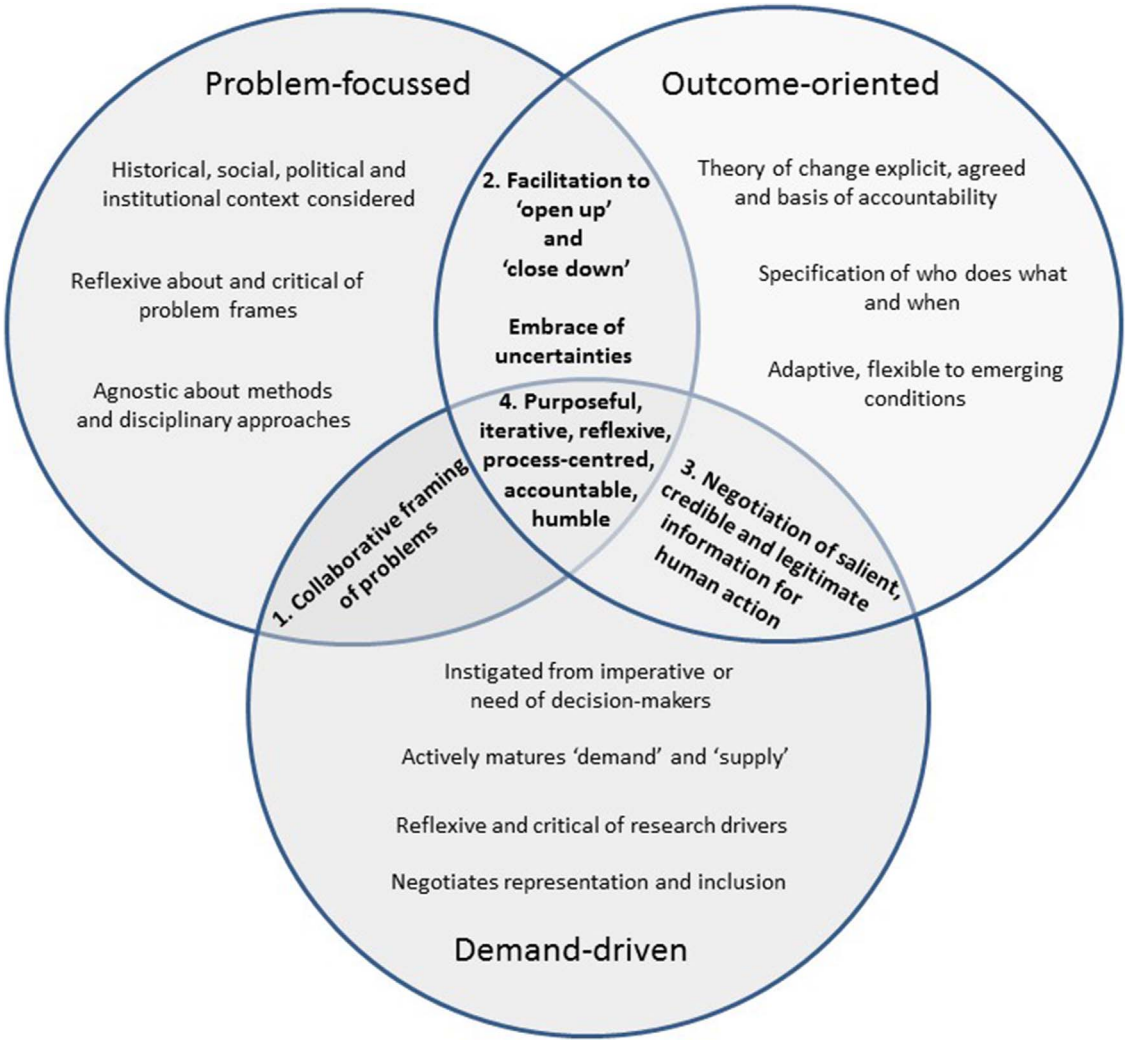
Problem-focussed
Historical, social, political and institutional context considered
Reflexive about and critical of problem frames
Agnostic about methods and disciplinary approaches
Outcome-oriented
Theory of change explicit, agreed and basis of accountability
Specification of who does what and when
Adaptive, flexible to emerging conditions
2. Facilitation to 'open up' and 'close down'
Embrace of uncertainties
4. Purposeful, iterative, reflexive, process-centred, accountable, humble
1. Collaborative framing of problems
3. Negotiation of salient, credible and legitimate information for human action
Instigated from imperative or need of decision-makers
Actively matures 'demand' and 'supply'
Reflexive and critical of research drivers
Negotiates representation and inclusion
Demand-driven

Fig. 1. Framework for RSD oriented by three normative goals and related principles.

project participants and program designers.

Our analysis firstly focuses on the development of the Regional Natural Resource Management (NRM) Planning for Climate Change Fund (hereafter, the program) both within the Commonwealth Government and among stakeholders. We draw on public documents and seven in- depth interviews with key players in program negotiations, identified through purposive sampling to seek diverse perspectives. Interviews were conducted in 2016, towards the end of the program, and four years after its instigation. Resulting recollections of program development were often a little hazy. However, the ability of participants to reflect on the differing positions in program development, how these manifested in the actual program, and then played out in practice provide a narrative richness that would not have been achieved through single interviews immediately following the development of the program. Also, the time lag means that many participants had changed jobs at the time of the interviews and were thus able to reflect more openly on positioning, power, politics and other potentially contentious issues internal to decision-making within a government agency.

Secondly, at a project level, the Southern Slopes Climate Change Adaptation Partnership (SCARP) was designed to undertake RSD-oriented action research with NRM planners across the Southern Slopes Cluster (see Fig. 2). One research aim was to reflexively analyse aspects of this RSD in practice.

Throughout the project, recordings and notes were taken of numerous formal workshops, interviews, and less formal discussions. These were supplemented by project evaluation data.

All data were first coded to explore issues pertaining to the elements of RSD in Fig. 1, particularly themes associated with the imperatives and principles at the juncture of demand-driven, problem- focused and outcome-oriented research. The interpretive approach used was an analysis of argumentative storylines (Hajer, 1995). Storylines are narrative elements that people use to present particular positions or beliefs (usually their own) as right and true, and other positions as flawed. Analysis of storylines is particularly useful in understanding demarcation and coordination of authority, legitimacy, credibility and relevance (Leith and Vanclay, 2015), otherwise known as boundary work (Gieryn, 1983; Jasanoff, 1987). The analysis of storylines is presented in Section 4 through chronological accounts of, respectively, the program design, and the unfolding of the project. In Section 5 the three lenses in Fig. 1 are applied to these accounts to detail key lessons for RSD from our attempted 'operation'.

First, it will be useful to briefly outline the regional model of natural resource governance in Australia. This model sees 56 NRM organisations (regions, Fig. 2) constituted differently under various state laws. NRM regions tend to focus on improving natural resource management on private land, especially by working with farmers, building capacity, and facilitating on-ground action through direct funding of works, market-based mechanisms, extension and, to a lesser extent, regulation. NRM organisations are responsive to funding programs, particularly from the Federal Government, and try to implement regional strategies through the vagaries of Australian political and policy changes.

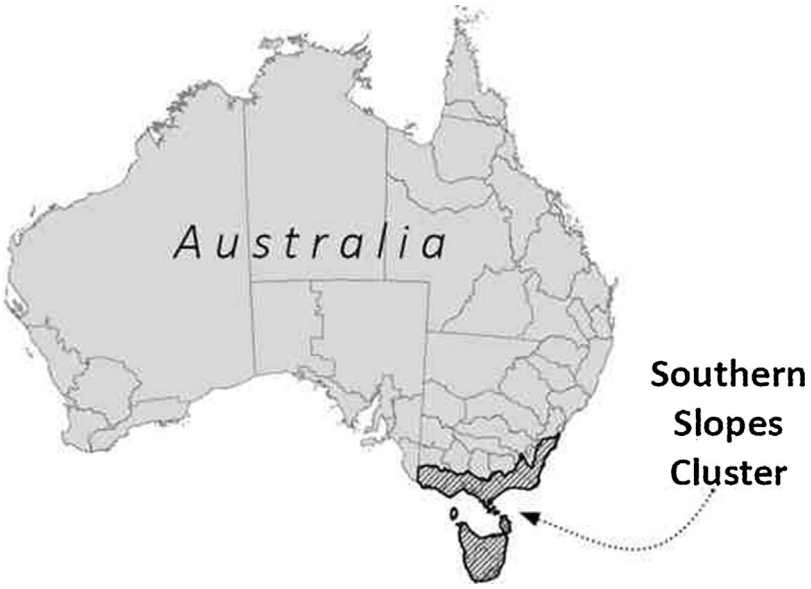

Fig. 2. The location of the Southern Slopes Cluster of nine NRM regions in south-eastern Australia.

Strategies are often described as 'community plans' as they contain NRM priorities for a region rather than an organisation, and guide activity among diverse stakeholders and across 'assets' such as coasts, biodiversity, agricultural land, freshwater systems, and community capacity. SCARP was a collaboration with nine regions across three states, that comprised the Southern Slopes Cluster: five regions in Victoria, one in New South Wales, and three in Tasmania (see Fig. 2).

4. Results

4.1. RSD in Australia's climate change adaptation NRM program

The political genesis and overarching policy rationale of the program was relatively uncontested among interviewees and coheres with the public record. In 2011, the minority Federal Labor Government was engaged in complex negotiations on climate change policy, particularly around greenhouse gas mitigation and sequestration. Three independent parliamentarians and one from the Australian Greens party, held the balance of power in the House of Representatives. Two of the cross-bench independents, as representatives of rural seats, eventually supported a highly politicised 'carbon tax' in large part on the condition that associated packages would benefit rural economies. The mechanisms for such benefit were a mix of incentives, voluntary instruments, regulatory controls, and research and extension programs. These were instigated under the Carbon Farming Initiative Act (2011) (hereafter the CFI) which was implemented through Clean Energy Futures Plan (CEFP) introduced in the 2012–13 Commonwealth Budget (see Fig. 3). Within the CEFP, the Land Sector Measures created "economic rewards for farmers who reduce pollution or store carbon and will protect biodiverse carbon stores and secure environmental outcomes from carbon farming." (Commonwealth of Australia, 2012, p. 41).

'Carbon farming' had the potential to change the landscape of Australia by making large scale tree planting economically viable through new carbon markets. Because trees planted under this scheme would need to remain for at least 100 years future climate conditions and their ecological implications needed careful consideration. Historical lessons about large-scale tree planting made the Australian Greens wary about the social, economic and biodiversity impacts of the scheme. For example in the 1990s, managed investment schemes created incentives to develop forestry plantations on private land that frequently became stranded assets and sometimes degraded rural economies which were left with long-term tree crops intensive agricultural industries had supported a viable local economy (e.g. see Ferguson, 2014). The Greens argued that such uncertainty and risk needed to be managed scientifically, at a regional level, and with communities. In this political and policy environment a variety of research groups, policy entrepreneurs and NRM leaders developed initiatives that aligned with the above priorities. These groups can broadly be classified as an 'adaptation planning discourse coalition' (following Hajer, 1995).

The CFI policy window opened at about the same time as cessation of Commonwealth funding to the core program for delivering climate projections, the Australian Climate Change Science Program.

Simultaneously, according to some participants, the release of Intergovernmental Panel on Climate Change (IPCC) AR5 projections created an imperative to develop the 'next generation' of regional modelling and downscaling for Australia. In many interviews, this imperative appears to have been largely taken-for-granted as obviously necessary.

Similar assumptions were not apparent in narratives about the development of RSD-oriented adaptation research prominent among members of the adaptation planning discourse coalition. For at least five years prior to the CFI, key researchers had attempted to shift national adaptation policy from being led by climate science to enabling adaptation through capacity and governance (e.g. Nelson et al., 2008). These researchers highlighted the limits of a linear 'predict-then-act model' of adaptation (Lempert et al., 2004), and, at the time of CFI policy development, ran a series of over 20 seminars and forums within the Commonwealth agency responsible for adaptation policy to explore how adaptation happens in practice.

This discourse coalition's membership was largely drawn from NRM organisations and the (then) Climate Adaptation Flagship within the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Interview accounts explain how this group very actively and explicitly organised and developed a coherent narrative about the need to enable climate adaptation across the NRM regions, especially through strategic planning and capacity building. As one participant suggested:

> There was quite a strong push from the discussion among the NRM groups that they didn't just want the climate data dumped out there. There was this whole issue of how you go about planning and using [climate information], and that was very important 'cos otherwise it might have just gone down this sort of climate science only direction, I think.

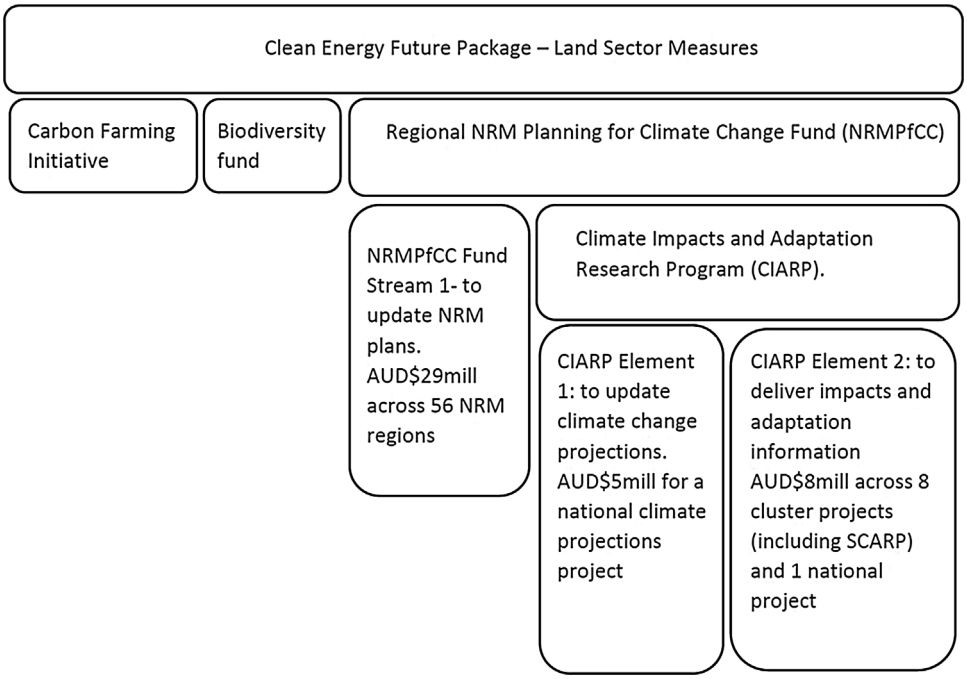
Clean Energy Future Package – Land Sector Measures
Carbon Farming Initiative
Biodiversity fund
Regional NRM Planning for Climate Change Fund (NRMPfCC)
NRMPfCC Fund Stream 1- to update NRM plans. AUD$29mill across 56 NRM regions
Climate Impacts and Adaptation Research Program (CIARP).
CIARP Element 1: to update climate change projections. AUD$5mill for a national climate projections project
CIARP Element 2: to deliver impacts and adaptation information AUD$8mill across 8 cluster projects (including SCARP) and 1 national project

Fig. 3. The structure of funding arrangements for research and NRM planning under the Commonwealth of Australia's Land Sector Measures of the Clean Energy Futures Package (circa 2012).

Accounts of this "push" included explicit description of efforts to 'lobby' government at a bureaucratic level by both researchers and Chairs of the NRM regions (see Section 4.2) for parallel and well- co-ordinated research and planning programs. CSIRO researchers were involved in drafting aspects of the program alongside Government staff. Yet the process of forming the program was anything but a straightforward collaboration. One participant suggested that:

> [T]he entire direction of that program came down to two sentences from a cabinet submission, which provided for massive interpretation. And of course set up quite a big fight in the bureaucracy about who was gonna… What priorities were gonna dominate that funding.

In the end, the Regional Natural Resource Management Planning for Climate Change Fund (NRMPfCC) was divided into $AUD 28.9 million for planning projects and $15 million for the Climate Impacts and Adaptation Research Program (CIARP) (see Fig. 3). Within CIARP the climate projections work was contracted directly to CSIRO and the Bureau of Meteorology, to a value of $AUD 5 million. Work commenced in 2012, nearly a year earlier than the impacts and adaptation research and the planning projects. The latter were supposed to run for four years, ramping up quickly over the first two years, then providing lower levels of support as NRM organisations revised and implemented their strategies. The $AUD 8 million for impacts and adaptation research was distributed through a competitive process across the 8 NRM cluster areas and one national project. The early emphasis on planning for carbon sequestration in the CIARP was broadened to include support for adaptation planning, information provision and integration of local knowledge. CIARP's central goal was "resilience of the landscape, communities and agricultural economies." A process-orientation emphasised in the funding call suggested an intent towards RSD over *a priori* specific research deliverables.

4.2. RSD for climate change planning at a project scale

The Southern Slopes Climate Change Adaptation Partnership (SCARP) was a four-year action research project under the CIARP, designed around normative elements of RSD (Fig. 1). Under Stream 1, planning projects could either amend an existing strategy with a climate change plan (which was done in Victoria and New South Wales) or develop a new strategy (Tasmania). In 2013 each of the 9 NRM organisations appointed a staff member to lead the project. These diversely skilled individuals became the primary points of contact between SCARP and the 9 regions.

SCARP's Steering Committee was comprised of NRM leaders from each of the three states as well as senior staff from SCARP's partner organizations (one University and State Government agency from each of the three states), and an independent Chair with high national standing in NRM. The Steering Committee provided high level oversight, input, and authorisation for project decisions. It included some members of the discourse coalition that had developed NRMPfCC and CIARP in the first place. They saw the potential for innovation via collaboration between researchers and planners and supported the research team to take time build relationships with NRM counterparts, and not rush into research activities. As one senior academic on the committee put it: "Don't just do something, sit there!" An NRM representative on the committee suggested that "the outputs are the people". Early SCARP interviews and focus groups with planners and leaders from the nine NRM organisations made it clear that their organisations had found research most useful when their own staff were members of research teams. These inputs framed and authorised SCARP's deliberative approach to RSD. While the approach clearly needed to meet program goals for the Stream 2 projects of providing the 9 NRM regions with impacts and adaptation information to inform their planning, it was also clear that the process of developing this information required iterative learning about what was possible and what would be useful.

An internal ethos developed among SCARP's core team—social researchers and an agricultural extension specialist—of being 'collaborators' with, and 'critical friends' of, the NRM planners, as well as a 'resource'. The expertise of NRM planners was consistently acknowledged, with researchers often deferring to individuals or the larger group, acknowledging the limits of existing research and highlighting the need for humility in the face of uncertainties about future climatic and other change. The researchers demarcated SCARP's role

carefully—SCARP would work with the NRM planners to understand what credible knowledge they needed in order to develop new 'climate-ready' strategies. SCARP would synthesise and (where needed) develop new, climate impacts and adaptation information that would be relevant across regions. New projections and scenarios would be integrated as much as possible but were being produced at a national level by the CSIRO climate projections team. SCARP could help individual regions to negotiate specific challenges related to climate change planning, but were not service providers or consultants that could be directed to do targeted research for any specific region. Independence and responsiveness were simultaneously developed through narratives highlighting various limitations of what was possible in working with and across regions with very different needs, while ensuring equitable value from SCARP across all nine regions.

At first these narratives were met with a general scepticism. In the first workshop that all nine SSC NRM planners attended, most made it clear that, in their experience, researchers were frequently extractive, using engagement and knowledge of NRM practitioners for their own ends—the delivery of pre-defined, publishable outputs.

At the same workshop, the CSIRO climate change projections team (Stream 2, Element 1, see Fig. 3) provided an overview of their project and its timelines leading one NRM planner to note that new projections would not be available in time to be incorporated into their strategy. The response—that the new climate modelling outputs were very similar to existing 2007 outputs, so the latter could inform plans instead—was met with indignation. The new strategies, the NRM planners argued, were to be predicated on the *new* projections information. NRM Boards and CEOs were expecting 'up-to-date information' to be used in plans. Novel information was obligatory because of its existence, whether or not it added any value.

Similar storylines about expectations and institutional legitimacy were common throughout SCARP processes. Planners emphasised the social acceptability of terms such as 'resilience' within their communities, compared to approaches that focus on negatives (e.g. 'vulnerability' or 'barriers'). Risk mapping was viewed as politically dangerous and described as 'raising red flags' for farmers. In many cases, in rural constituencies, among Boards and even within NRM organisational leadership, anthropogenic climate change was disputed or rejected. Stream 1 planners had inherited the task of engaging with these diverse and often divided communities about climate change and saw this challenge principally as a social and political one for which many felt underprepared.

Iterative conversations, meetings and workshops ensued. We drew on various framings of adaptation from work on barriers (e.g. Moser and Ekstrom, 2010) to pathways approaches (Haasnoot et al., 2012) to address practical and personal concerns. Beyond the adaptation literature, SCARP's early work to open up the problem of adaptation led to discussions about how ambiguity, uncertainty and ignorance allowed for exploration of more social and human elements than managerial approaches to adaptation in the predict-then-act paradigm (see Leach et al., 2010). SCARP's NRM partners rapidly adopted language and ideas of adaptation pathways as a pragmatic means of working with these forms of uncertainty with communities and groups (Bosomworth et al., 2017). Classification of different types of pathways was, for instance seen as a useful device to distinguish between maintenance of the *status quo* through resilience/buffering approaches of those approaches that attempted to transition or transform social or ecological systems (Pelling, 2011). In such dialogue NRM planners recognised their organisational and personal commitments to conservation as oriented to resilience and buffering ecosystems from change. These commitments were inscribed in strategies via objectives to "maintain or enhance" the condition of given systems or assets. Discussions highlighted how deeply entrenched such commitments had become in the language, science and governance of NRM, and that these commitments avoided growing likelihood of loss, decline or collapse of some systems due to climate change.

After the first six months of engagement, four research and synthesis sub-projects were developed: pathways planning, specific data syntheses, spatial prioritisation and ongoing collaboration through workshops and forums. SCARP developed an online portal where the content could be negotiated remotely (Wallis et al., 2017) as planners engaged with material and began to draft strategies.

The project's timeline was disrupted by a newly elected national Liberal Government which dramatically changed climate policy and abolished the NRMPfCC and CIARP. While contracts were honoured and the research streams remained unmodified, deadlines for expenditure of planning funds were brought forward along with due dates for delivering final plans. As SSC planners scrambled to contract consultants to finalise work they had planned to do within their organisations, their 'demand' shifted. SCARP outputs (including products) were needed earlier than expected.

A series of peer-reviewed reports relating to each of the sub-project outlined above now sit on a website. These provide authoritative advice on matters ranging from ways to frame complex problems with communities who disagree about goals and means of achieving them, to defining approaches to spatial prioritization planning for adaptation, to synthesis of the literature on impacts of climate change on many different ecosystems and natural resource processes in south-eastern Australia. These reports were widely-cited in nine newly minted NRM strategies for climate adaptation. They outline a suite of approaches, attending to the latter part of one planner's summary evaluation of SCARP: "I've got the courage to say this is the approach and here are the tools". Another suggested:

> SCARP has assisted [my NRM organisation] to learn how to best access the relevant information as well as improve how to engage with its stakeholders to determine appropriate adaptation responses (i.e. through applying adaptation pathways). This was more beneficial than providing the information itself.

Such quotes demonstrate how RSD can legitimise particular forms of action and learning. This is an idea that was widely expressed by planners working to deadlines in complex organisational environments. Although the reports argue for collaborative processes in much adaptation work, and were themselves generated through collaborative processes, to some degree they cover the tracks of this genesis. We go on to discuss this idea and its significance in the next section, but before doing so, it is worth pointing out that the usefulness of RSD activities that build capacity, confidence and 'courage' were not always valued. In one case, a planner suggested that SCARP's engagement was "mostly a waste of time" and that adaptation information was "limited to explaining 'how we should do it' rather than outlining what are the key impacts and discussing options specific for [my region]". Such a view suggests that some participants see themselves as 'information users' and the role of researchers as providers of information. Nevertheless, for all but one SSC NRM planner, the challenges they wanted help with related primarily to *how to do adaptation*.

5. Discussion

Reconciling supply and demand (RSD), as we have framed it, is process- and outcome-oriented work. Unlike Sarewitz and Pielke's (2007) focus on assessing the achievement of RSD, we have depicted RSD as processes spanning program design and the conduct of a subsidiary project. In this case, RSD at a programmatic scale was developed through discourse coalitions among researchers and relevant decision-makers. They built coherent policy narratives, constituency support, and lobbied to promote particular policy options to supplement traditional scientific (supply-driven) framings of adaptation. At a project level, work was more oriented to capacity building to develop and use credible knowledge among planners and researchers through collaborative enquiry and learning. Such enquiry is tempered by who participates and their social, cultural and epistemic perspectives; SCARP

was both enabled and limited by a relatively cohesive group of researchers and planners. No indigenous voices were present for example, and the one planner with a more technocratic view of decision-making appears to have been somewhat alienated by SCARP's process-orientation. Group cohesiveness was founded on iterative, pragmatic and collaborative development of problem framing, knowledge and ultimately capacity for adaptation, in which scientific information was seen as a necessary but insufficient means to achieve the complex and changing ends of adaptation.

In retrospect, despite commitments across the adaptation planning discourse coalition and the project collaborators, neither the program nor the project look substantially different from more linear, delivery-oriented endeavours. Formal outputs were reified as the *sine qua non* of success, simplifying the iterative and messy processes necessary for collective knowledge production and capacity building. As scholars of STS have often pointed out, science necessarily hides the messiness of its methods (e.g. Star, 2010). Yet in SCARP, as in many complex sustainability challenges, while salience and legitimacy of *knowledge* depends on processes, and relationships and the trust built through them, the wider authority of *information* rests on the appearance that such human and social phenomena never happened—that is, it hinges on peer-review and credibility ascribed through related academic merit. A suite of institutions prioritise information over learning, knowledge or capacity building. In this case, delivery of formal outputs allowed for instrumental evaluation of success within the relatively short-time frames of projects, providing cheap, formal measures of evaluation. They play into the ideals of "evidence-based policy" that provide a convenient front-of-house delineation of research and decision-making, and justification for public organisations to accrue information to support evidence-based decision-making, even when it is clear that most decisions are made through non-analytic judgement (e.g. Feldman and March, 1981).

Another way of considering this idea is that much research practice happens below a horizon of visibility (Fig. 4). Just as the visible part of an iceberg is supported by larger mass of ice, RSD processes build capacity and knowledge that makes information formalized in reports and other outputs into useable information by a specific group of people. Below the line, uncertainties, confidence, ideals and ethics are grappled with in often uncomfortable and messy processes that require honesty and humility. Above the line, products codify knowledge as transferrable information, they legitimate courses of action as methods, they present clear lines of argument, well-referenced sources of information, and they appear to reinforce linear and deficit myths of rational action founded on science. We refer back to this metaphor, illustrated in Fig.4, in reviewing lessons about the application of RSD as problem-focussed, outcome-oriented and demand-driven, through examining aspects of the program development (NRMPfCC and CIARP) and the project (SCARP).

5.1. Problem-focused

The adaptation planning discourse coalition developed a cohesive framing of the problem of NRM adaptation, which substantially informed CIARP development. For them, the central challenge was to build capacity and knowledge for a new planning paradigm. The default framing of adaptation was described as a technical and managerial one, dependent on delivery of information founded on climate projections as the basis of adaptation. This is evidenced partially by the prioritisation of climate modelling through the taken-for-granted policy assumption that adaptation relied on updated modelling of climate drivers to allow impact and vulnerability assessments, and an unquestioned commitment to the primacy of such activity. While the adaptation planning discourse coalition recognised the value of such projections, it attempted to reframe this value within demand-driven research that built capacity to adapt through planning as a learning process. For example, in making the case that 'the people are the outputs' an NRM leader foregrounds the idea that people address problems. In this view the value of climate projections to NRM planning depends on capabilities of people to use ambiguous information in complex settings, such as the community or board meetings in which planning and implementation decisions are made. Thus the discourse coalition articulated components into a systems view. Argumentative storylines here were not explicitly opposed to climate projection or black and white about roles and priorities. Perspectives tended to lean towards and borrow from scientistic and relational traditions indicating a predilection to integration or at least coordination and accommodation, rather than competitive opposition. For instance, 'science delivery' associated with climate projections were incorporated into complex and disruptive narratives that foregrounded people, institutions and structural failures by the adaptation planning discourse coalition.

At a project scale, SCARP was explicitly able to unpack aspects of the problem of adaptation with planners, exploring and ultimately attempting to articulate aspects of the larger problem ranging from institutional and cultural barriers to adaptation, to various forms of uncertainty around ecosystem impacts. All collaborative efforts to frame and address problems were ultimately legitimated by a reversion to the visible, above-the-line products. While the participatory processes made these outputs legitimate to planners, peer-review and publication of glossy reports were obligatory passage points (Callon, 1986) that enabled planners to make this knowledge credible within their organisations and more broadly.

5.2. Outcome-oriented

In collaborative processes, objects can helpfully mediate processes providing points of focus for negotiation, contestation and agreement (Star, 2010). In SCARP, mutable boundary objects such as conceptual models, diagrams, maps and 'climate-ready objectives' were explicitly

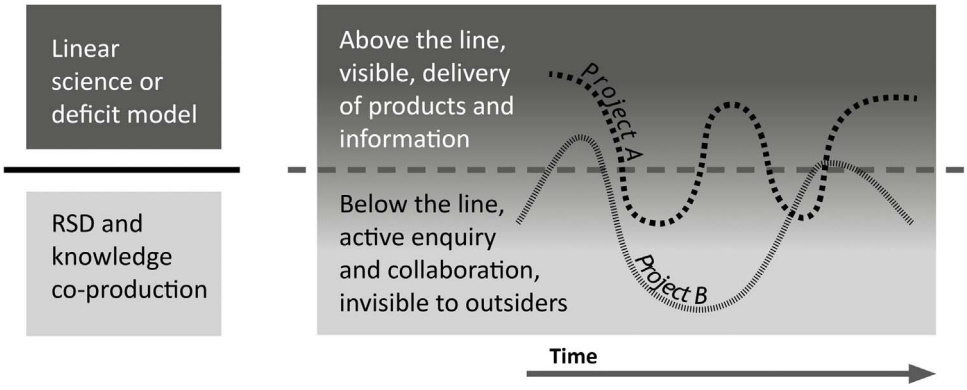
Linear science or deficit model
RSD and knowledge co-production
Above the line, visible, delivery of products and information
Below the line, active enquiry and collaboration, invisible to outsiders
Project A
Project B
Time

Fig. 4. Visible and invisible work in RSD-related projects that occurs above and below a line of external visibility.

used to facilitate learning and to identify means to achieving ends. Although these deliberative means of opening up and exploring challenges to inform planning were cut short for political reasons, planners saw longer term outcomes. They acknowledged that they were developing less-than-perfect plans, but these needed to be viewed in the context of long-range adaptation over decadal timescales. They were keen to continue learning through implementing plans and in doing so finding their faults, failings and limitations. In line with the process orientation of SCARP, outcomes were collectively constituted by SCARP and its NRM partners as ongoing learning to achieve adaptation through linking research and practice. This focus tended to depict individuals as agents of change within organisations. In this view, planning or policy documents appear as necessary above-the-line mechanisms of accountability and transparency that support action among individuals and organisations. Yet it was also clear, that because of the visibility of such objects they often have institutionalised priority over the people, dialogue, critique and enquiry that enables adaptive learning and governance. Another way of putting this—and this observation varied greatly among NRM organisations—is that some NRM organisations collect information and lose people, and they invest accordingly.

If learning, at individual and institutional levels, is considered as a means to achieving larger scale adaptation objectives, then the relationships between above- and below-the-line work might be more actively considered in science policy. This would imply that research funders attend to the rigour of processes and governance associated with defining and reaching milestones within collaborative projects. Such process focus is outcome-oriented because it takes seriously the implementation of a theory of change—in this case one that hinges on the capacity of people, organisations and institutions—while remaining adaptive in the face of emerging understanding.

5.3. Demand-driven

A central idea of RSD is that demand is naïve of supply, and supply unaware of the nuances of demand. Both need to evolve together to firstly frame problems and then define options for addressing them. In our account, this negotiation of supply and demand occurred throughout the program development and the project in different ways until their respective points of closure (signified by publication of a funding call and selection of projects [CIARP] and final research outputs and new strategies [SCARP]).

While SCARP drew on participatory approaches, it also depended on disciplinary expertise. In fact, it required iterative shifts between collaborative knowledge production, negotiation, and linear delivery approaches. Where McNie et al. (2016) suggest that projects might be typified as existing along various spectrums related to activities such as knowledge production, learning and engagement, and organisational and institutional processes, SCARP would be hard to map onto such a framework. SCARP's role frequently shifted from demarcating credible knowledge to coordinating processes and content that would be relevant and legitimate across regions. For example, in the Tasmanian context, with a whole of strategy review in process, SCARP shifted from taking a role as expert adviser on specific points, to critical friend among a wider network of stakeholders. In Victoria, where the focus was more firmly on implementing a pathways approach to adaptation, SCARP researchers took on roles as collaborators, working with NRM planners to apply expertise in adaptation processes.

It is less clear how the demand-driven elements of RSD occurred among the adaptation planning discourse coalition and those who advocated for a greater emphasis on climate science in the development of program priorities. A history of politicisation was apparent in some accounts, especially among members of the adaptation planning discourse coalition who considered their coalition building as working counter to a strong supply-side 'push' from the 'climate science lobby'. Others, apparently less aligned with this coalition still stressed the importance of communications and engagement, largely to ensure that planners could access and use climate impacts and projections information appropriately. While it appeared clear to all that high-quality climate projections were *necessary* for adaptation planning, the adaptation planning discourse coalition was also concerned with sufficiency of knowledge and capacity at institutional and organisational levels to do the diverse work involved in adaptation.

Research focused on spanning science-policy-practice boundaries has tended to suggest specific roles of actors (Pielke, 2007), processes of engagement (Cash et al., 2003) or that structures and institutions (McNie, 2007) are necessary to ensure that information is relevant, credible and legitimate within given contexts and settings (Dilling and Lemos, 2011). Sarewitz and Pielke (2007) similarly focus their assessment of RSD on the benefit and relevance of science-derived information to achieving outcomes. Our analysis suggests that fostering knowledgeable and confident people was a more important outcome of RSD than the development of information *per se*.

Nevertheless, the above the line delivery of information products serves many deeply institutionalised needs of funders and decision-makers: they provide countable items for reporting purposes (cf. Scott, 1998); their delivery marks an endpoint of project; they codify a coherent authoritative perspective; they fulfil institutional desires to collect information (cf. Feldman and March, 1981), and; they provide legitimizing resources to support action. These are not insignificant contributions. Yet for above-the-line outputs to lead to larger societal outcomes they need to be taken up, deployed or acted on, and this will often require below-the-line activity to enable actors to use their content appropriately and effectively.

SCARP's primary objective became: to build capacity to use partial knowledge from across the biophysical and social sciences as a basis of adaptation planning and implementation in NRM. This relied on commitments to the principles of RSD. It also required pragmatism to achieve imperfect, adaptable but useable resources, such as approaches to pathways planning for Australian NRM. Such activity is not RSD of *information* per se, but facilitation of collaborative action to build knowledge and capacity to use it to achieve specific objectives. While the SCARP experience was largely positive, it foreshadows risks for future operations on the 'neglected heart'. For instance, RSD requires attention to who is involved and how—people, organisations and institutional settings should neither be so diverse as to forestall learning or so narrow as to curtail it. Expanding on this idea, RSD can be seen as a form of pluralistic knowledge production that must recognize, and actively and adaptively manage its democratic, epistemological and ontological settings to foster pre-defined outcomes.

6. Conclusion

In this account of a cross-scale operation on the 'neglected heart of science policy' we have suggested that, when knowledge production is actively conceived within the emerging paradigms of sustainability science, reconciling supply and demand is not *primarily* oriented to creation of information for decision- makers. RSD necessarily works to open up and actively reframe problems and possibilities. This means that RSD must challenge existing frames and naïve supply-side push and demand-side pull. Even where knowledge gaps persist and are considered substantial (such as in planning for an uncertain future), RSD must acknowledge that these are not necessarily filled by information. In our case people with knowledge and the capacity to use it to good effect in specific contexts were the primary constraint and focus. Through SCARP the majority of NRM planners appear to have benefited from the RSD process. This was not solely because information was deemed relevant, credible and legitimate. Participants frequently reflected on their growing courage to lead efforts towards adaptation within their organisations and communities. Ultimately, SCARP's reports were an institutionally necessary means of legitimising those actions, based on knowledge gleaned from an extended collaboration.

However, this case demonstrates that even where there is broad recognition that 'the people are the outputs', existing epistemic, cultural and institutional settings can still lead to prioritization of information based products. Reports were prioritised as an assumed means by which research contributes to complex ends. Fixation on information products is an understandable institution, and we do not argue that it or the nostrums of 'delivery' be entirely rejected. In fact, in this case, reports and other outputs were constituted as subsidiary enablers that people and organisations required to legitimise adaptation in practice.

Because RSD intentionally works to re-examine how problems are framed, its processes may be particularly effective in emerging areas of science-policy interaction, or ones in need of renewal. While we suggest that frameworks such as the one presented for RSD in this paper might usefully inform design and evaluation of such processes, further work is needed across different contexts to understand the universality or otherwise of our proposed principles. Moreover, the relational intensity of RSD will remain a challenge where linear narratives of science policy, impact and attribution persist.

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